Progress on MGI and RE confinement modeling

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CEMM meeting

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Outline

Part I. Massive gas injection in DIII-D with applied n=1 fields

- Brief review of previous MGI results (no applied fields)
- Simulations with n=1 fields

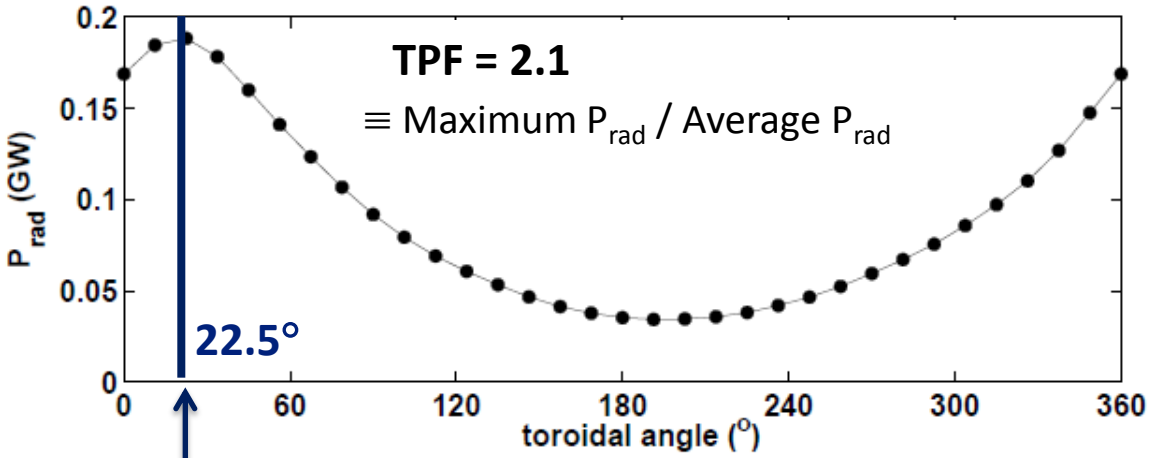
Part II. Comparison of RE confinement with "pellet-like" vs. "MGI-like" source terms

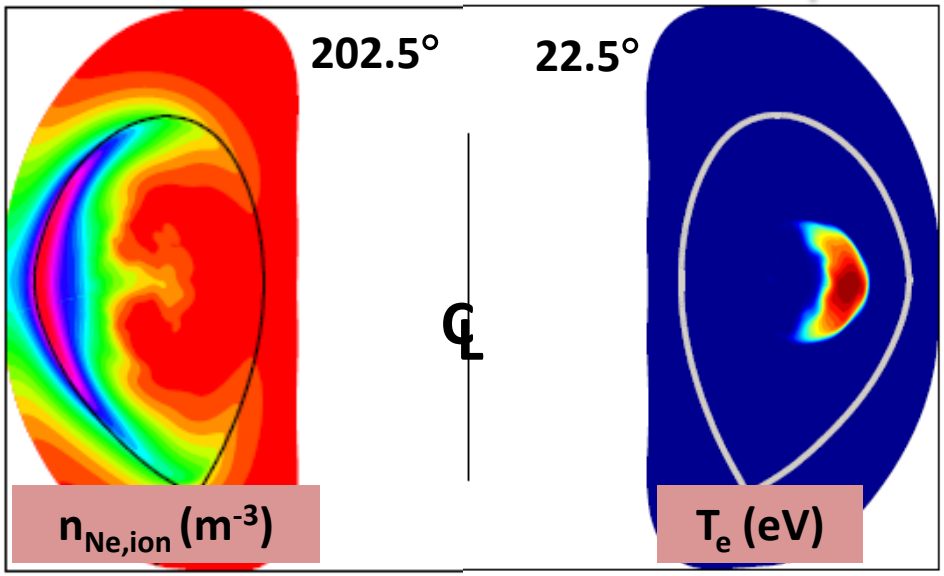
- RE modeling of Ar pellet shots
- Ne MGI simulations

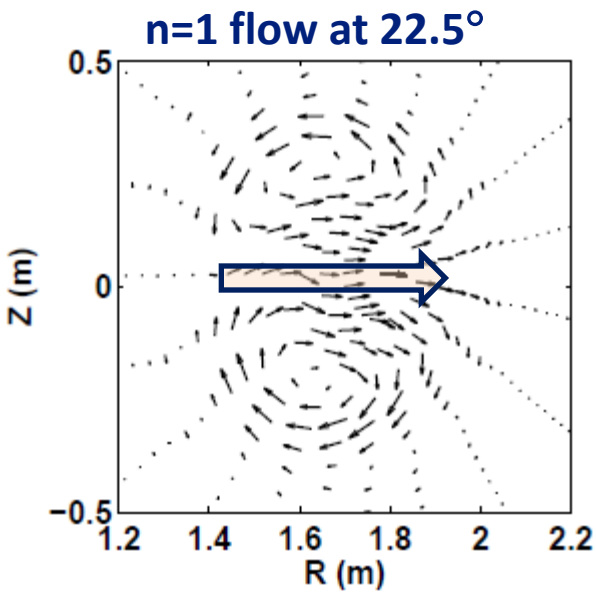
Summary

Part I. Massive gas injection

Results from APS– even with toroidally symmetric gas injection, toroidal peaking in radiated power occurs due to 1/1 mode. Toroidal peak is at location where hot core is expelled toward high impurity region







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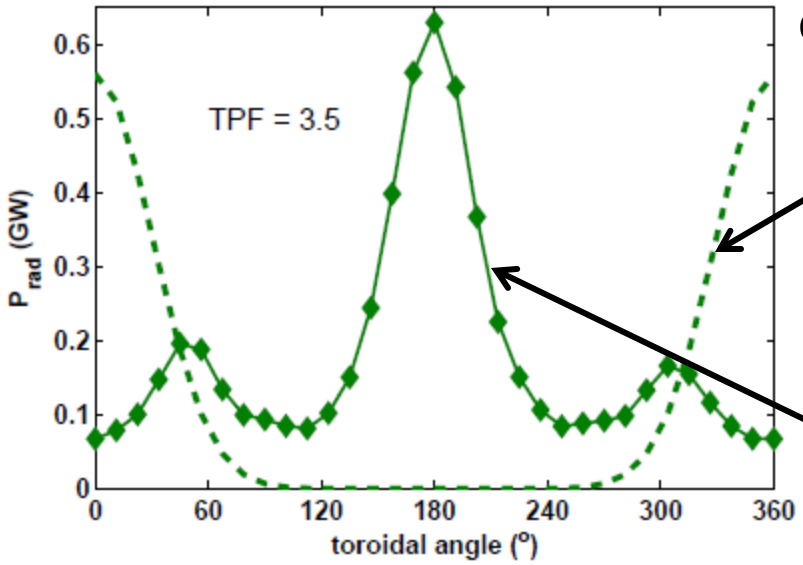
For localized MGI, 1/1 mode always orients heat flux away from the jet location

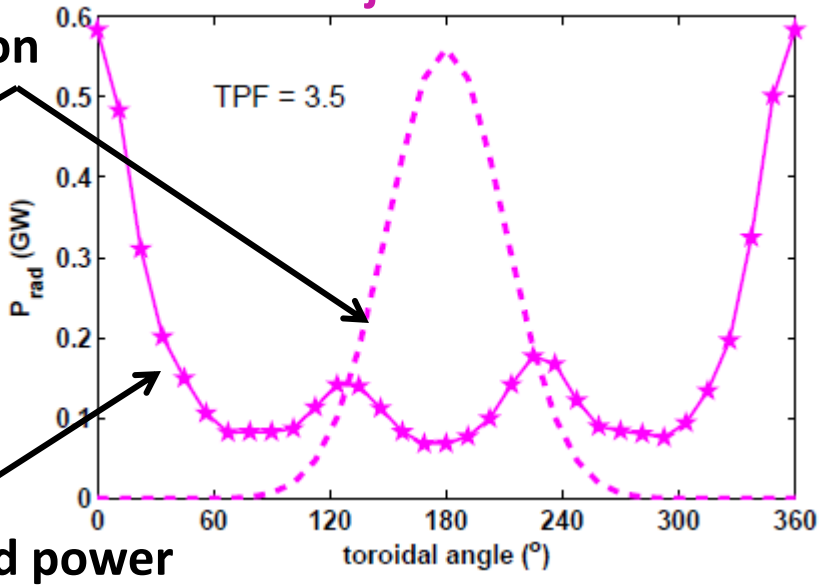
Gas jet at 0°



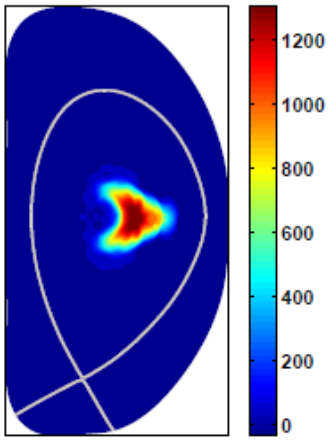
Impurity source distribution

Radiated power distribution

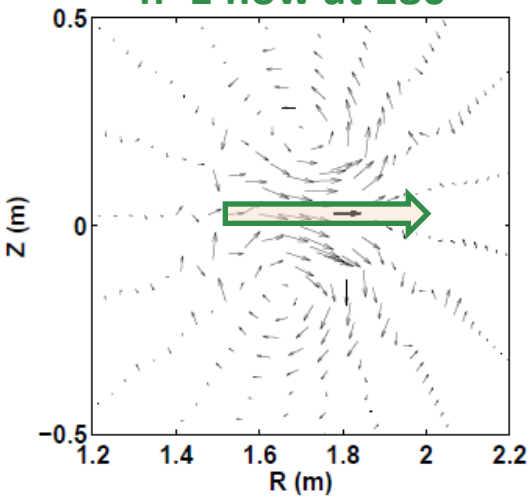
Gas jet at 180°



T_e at 180°



n=1 flow at 180°



In simulations, jet location controls mode phase. What about in experiments?

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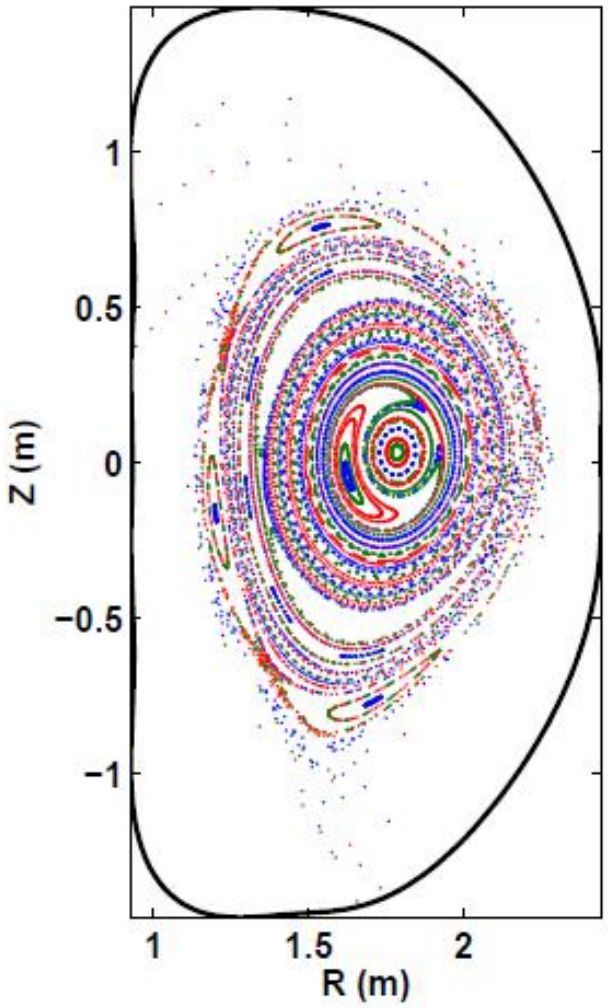
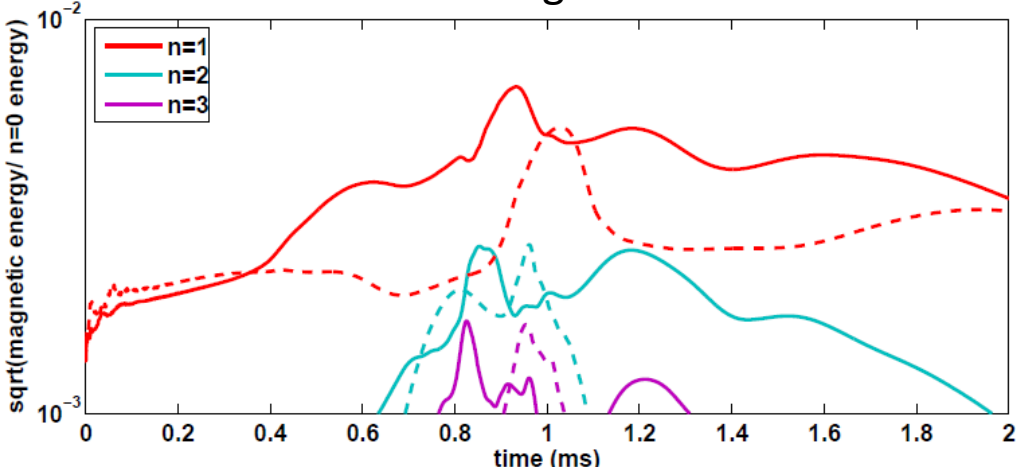
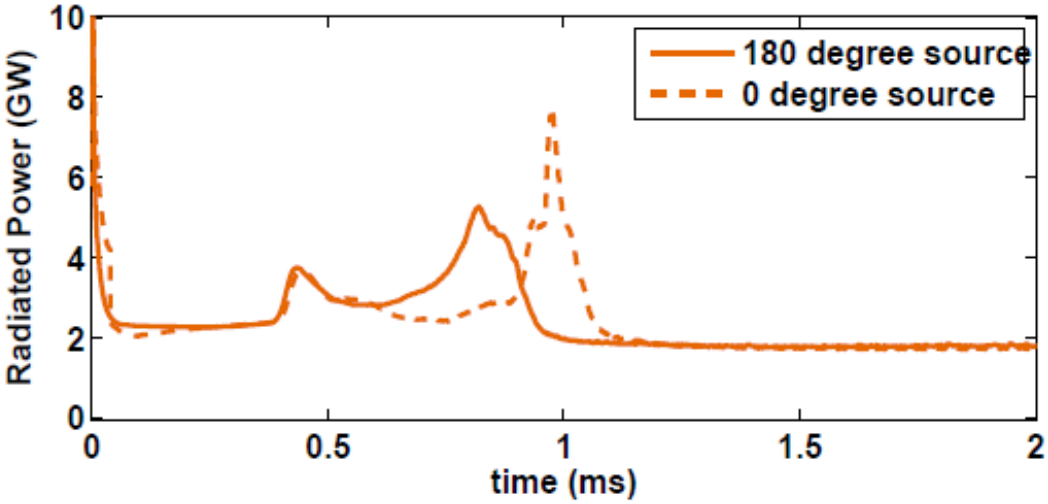
Two simulations have applied n=1 fields (same phase) with localized MGI (opposite phase)

Vacuum Fields



For 0° source, applied fields are anti-aligned with preferred mode phase. For 180° fields are aligned with mode





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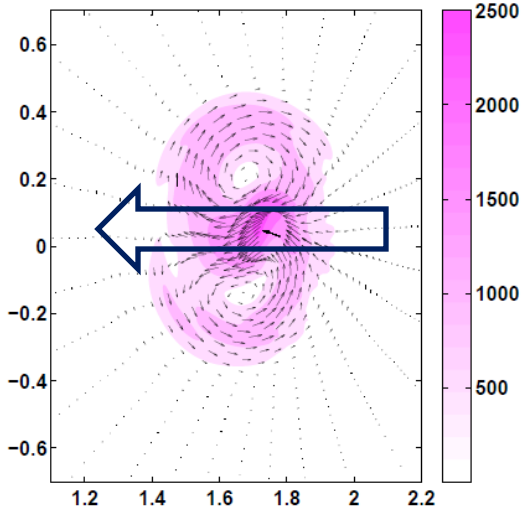
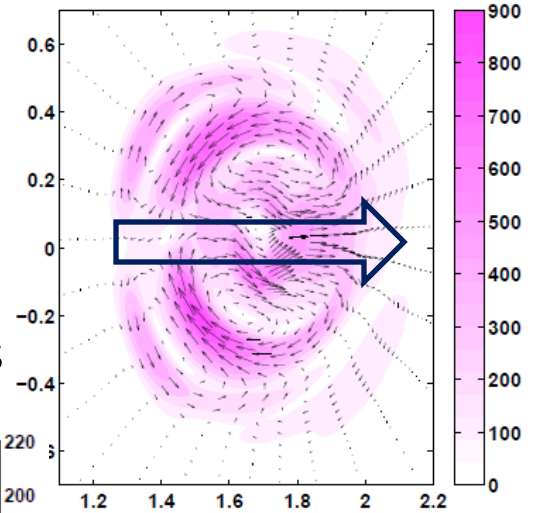
In either case, phase of mode is still such that heat flux is away from the impurity source

n=1 poloidal flow at ϕ=0° at 1.0 ms

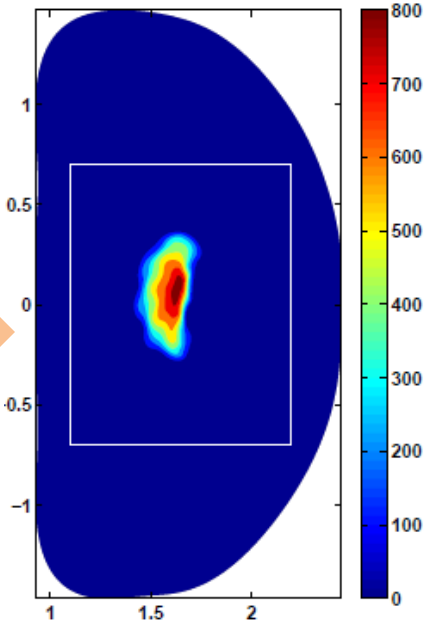


Applied fields have same phase but source location flips. Mode phase flips→ determined by jet location just as in prior simulations. Applied fields don't force 1/1 phase.

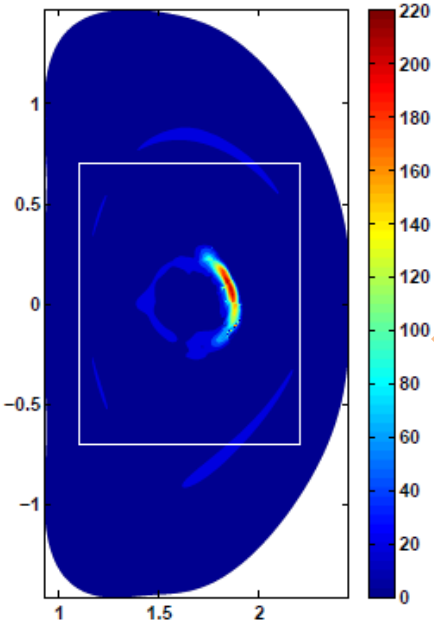
n=1 poloidal flow at ϕ=0° at 0.95 ms



Temperature at ϕ=0° at 1.0 ms



Temperature at ϕ=0° at 0.95 ms



Source at 0°

Source at 180°

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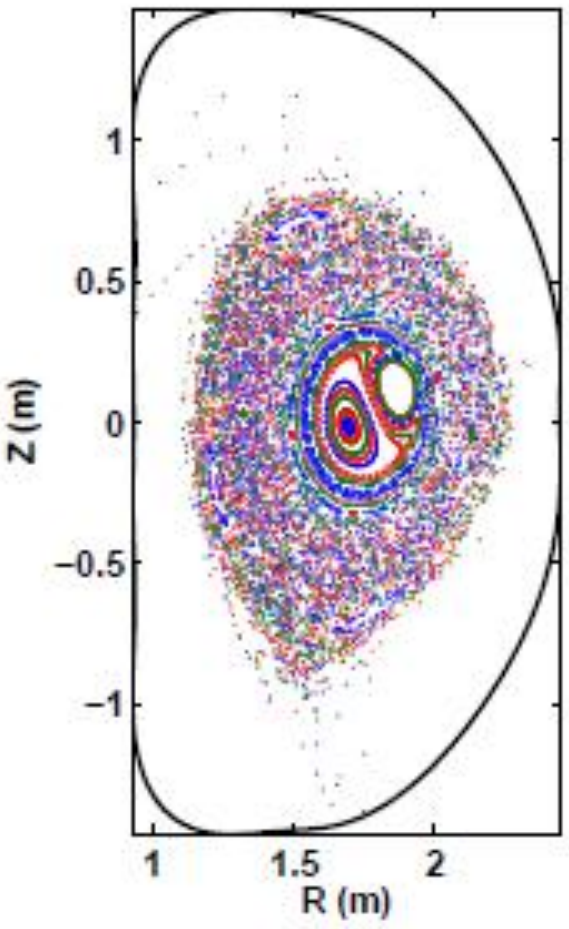
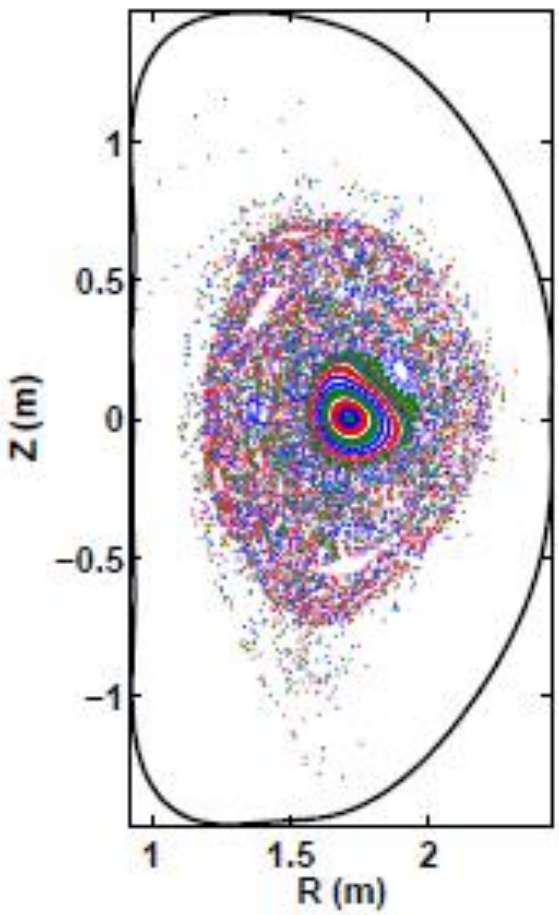
Imposed 1/1 island heals before TQ (0° source)

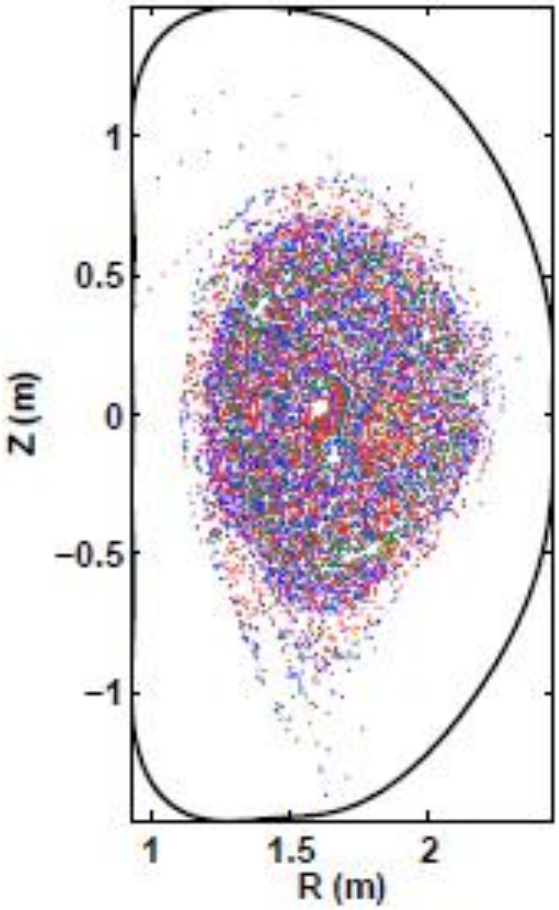
Time = 0.5 ms



Time = 0.8 ms



Time = 0.95 ms



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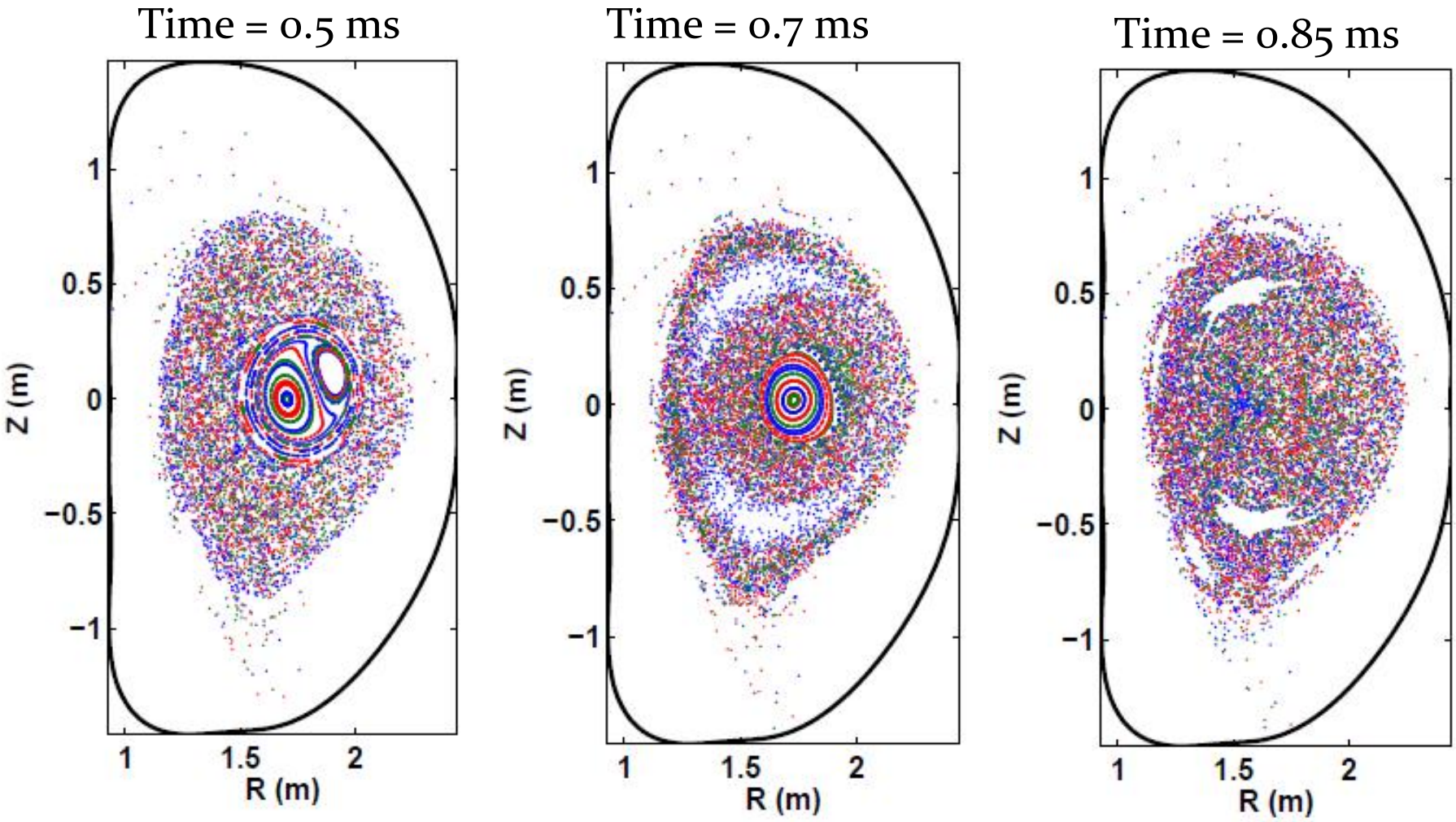
For 180° source, field lines look very similar



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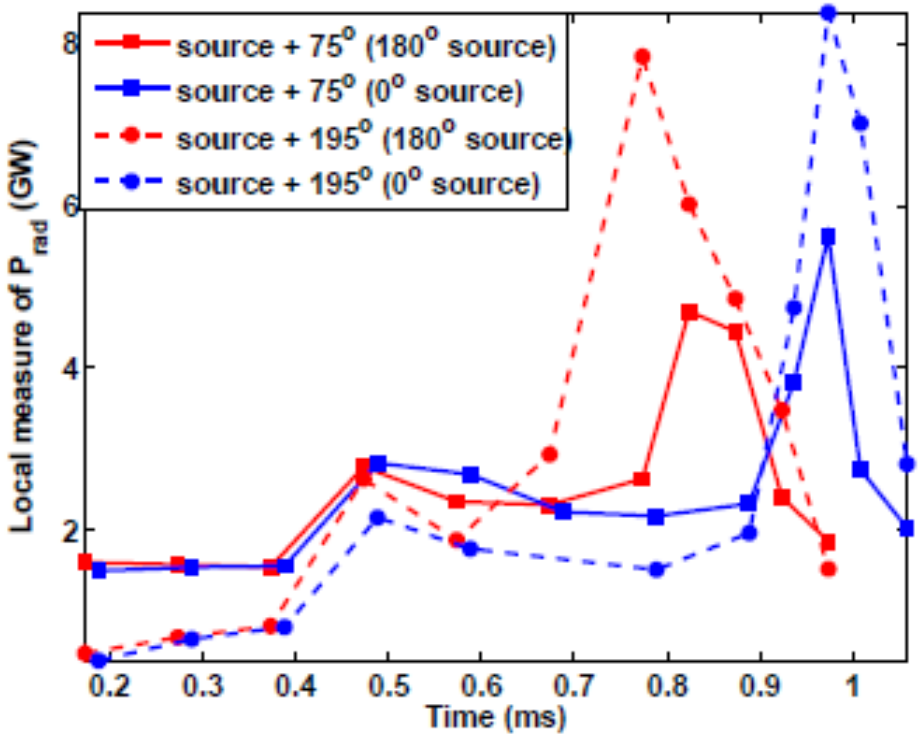
Upcoming DIII-D experiment (June). Hope to lock mode to n=1 I-coil fields

- Experiment will apply n=1 fields with I-coils prior to MGI. Phase of applied fields will be varied from shot-to-shot

- If we really can force the mode to take a particular phase (despite simulations results), significant variations in locally measure radiated power may be observed.

- Even if mode phase does not change, simulations suggest some effect should be observed.

Very crude synthetic diagnostic



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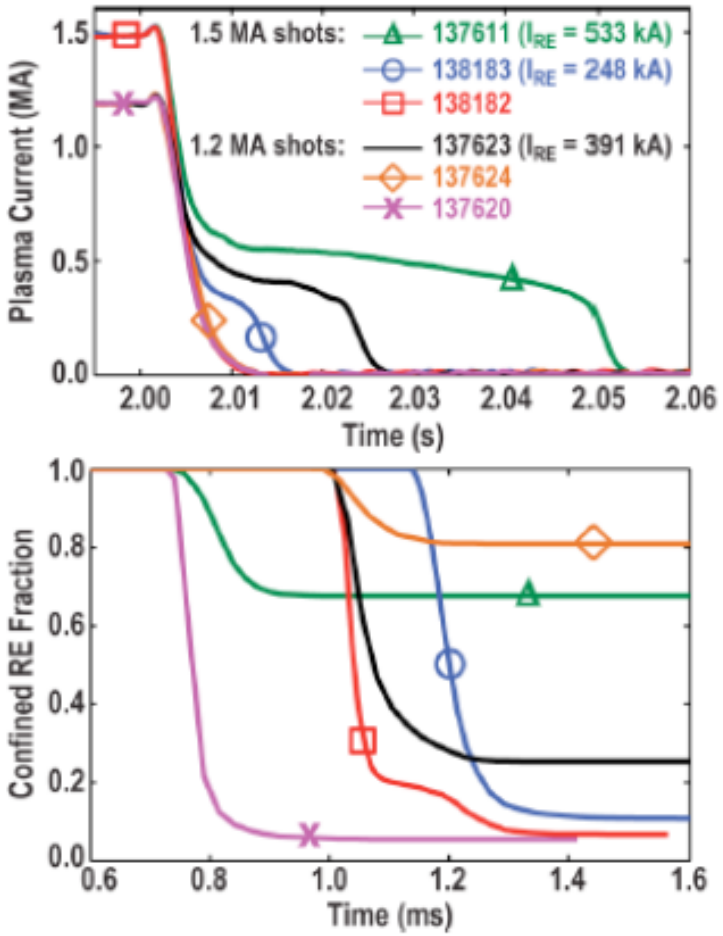
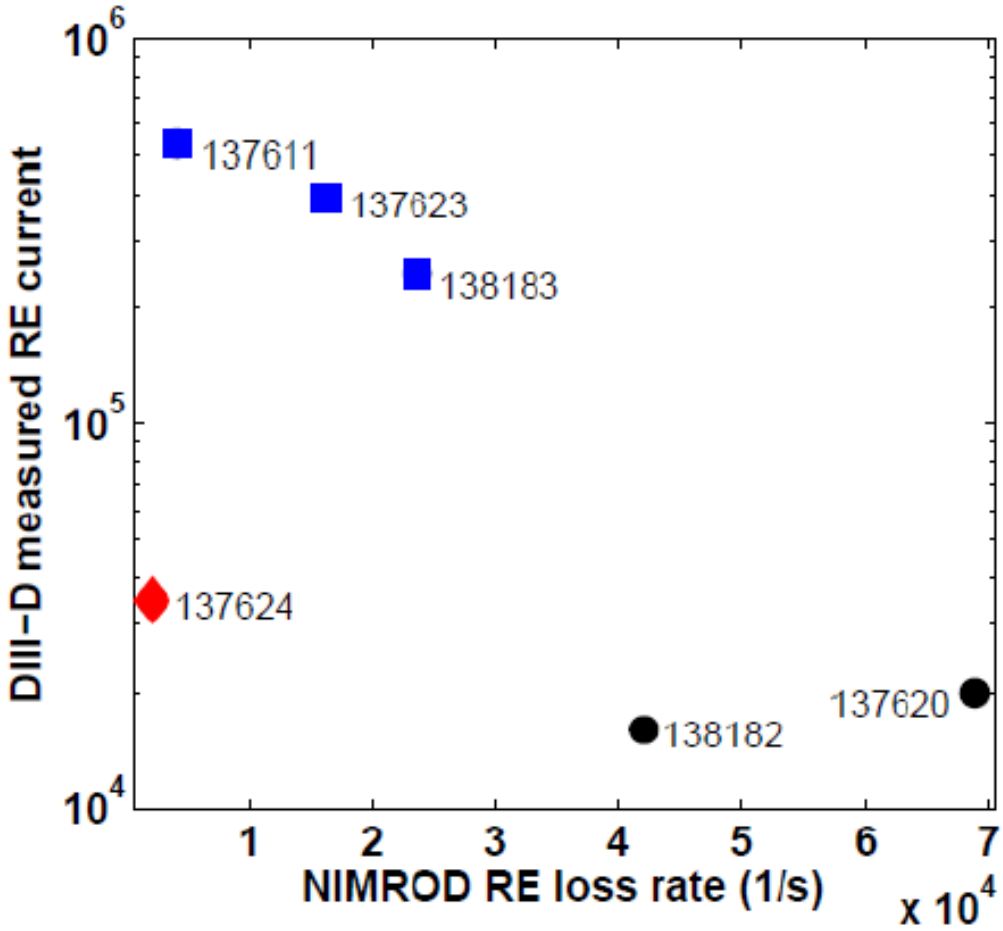
Part II. RE confinement (Theory Milestone)

Previous simulations RE losses during Ar pellet injection in DIII-D showed significant agreement with experimental RE current results





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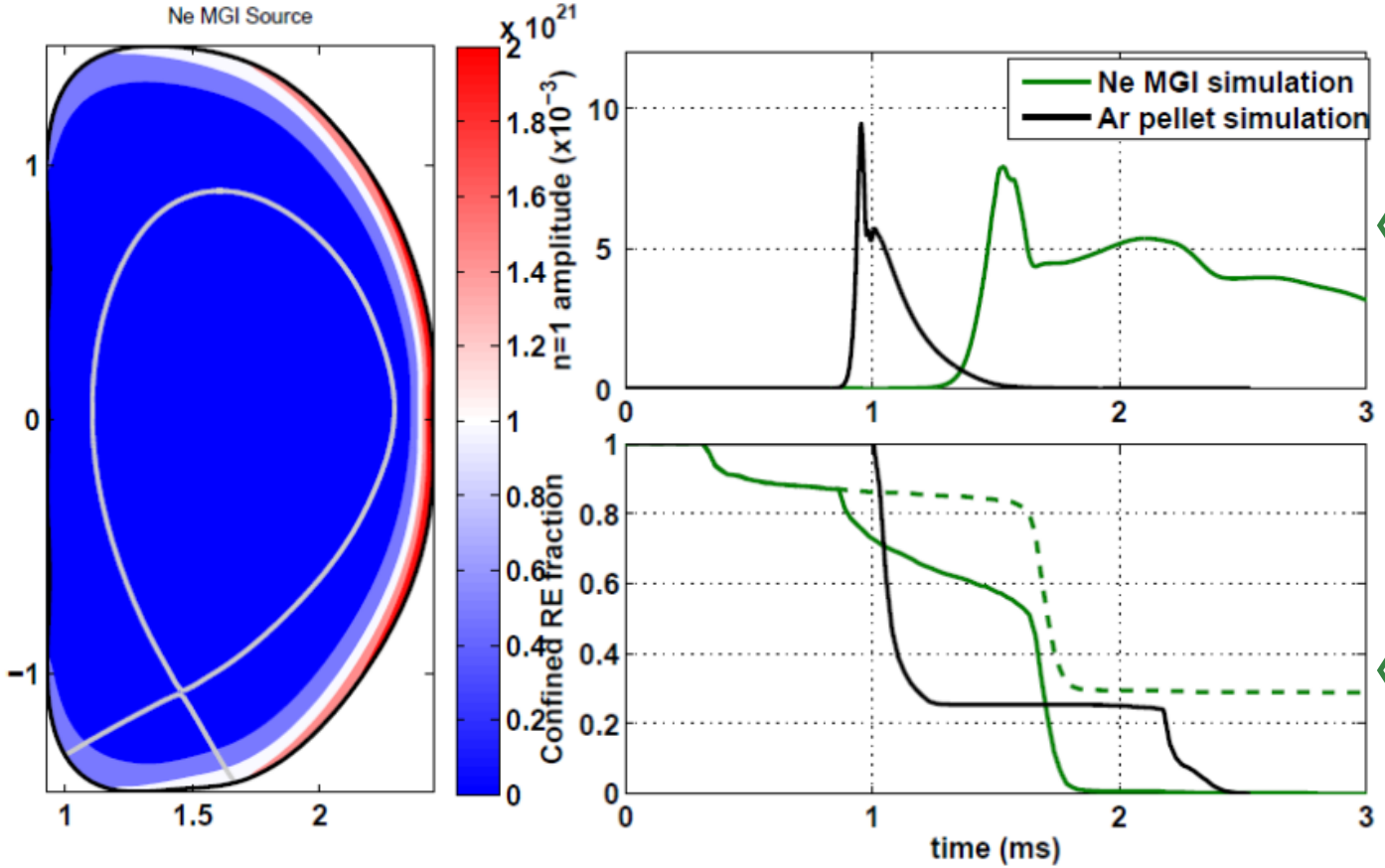
RE confinement results for MGI simulation

Toroidally symmetric Ne MGI-like source (shot 137623)



With MGI, core is less resistive both before and after TQ; n=1 mode is slower growing, and longer-lived

Dashed line is all tracked electrons. Solid line are only suprathermal electrons. Some seeds thermalize before TQ

MGI loss rate is 2.3×10^4/s

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RE confinement results for MGI simulation

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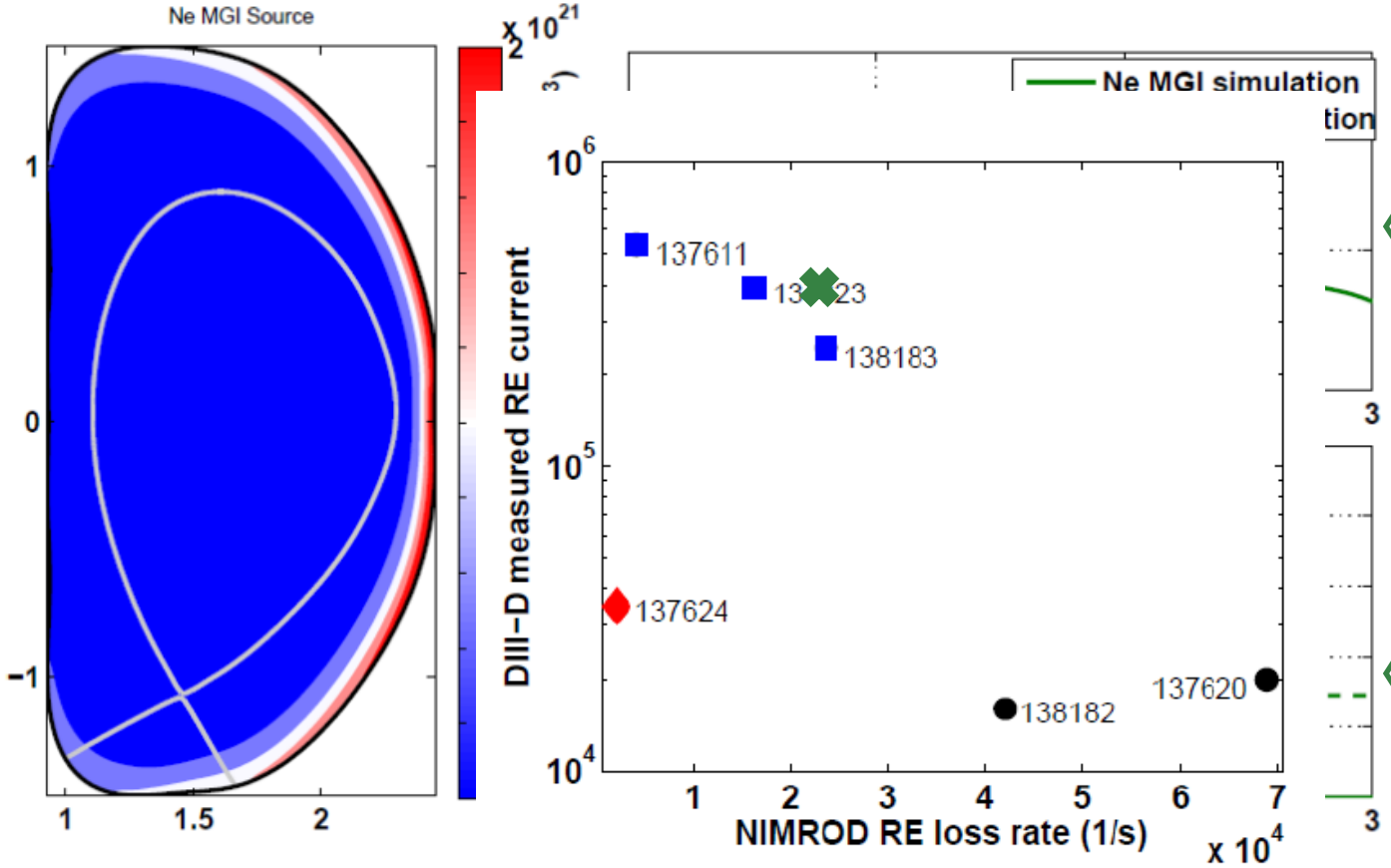

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Results suggest REs less likely after MGI for three reasons

1) Slightly higher RE loss rate

2) Significantly longer duration for large amplitude n=1 mode (due to less resistive core).

3) Pellet cools core before MHD onset→ seeds can form then have time to reach higher energy (improves confinement) before fields become stochastic

MGI does not cool core until TQ→ pre-existing seeds will tend to thermalize, seeds formed as confinement is lost will be low energy (poorly confined).

This is all consistent with DIII-D operational experience→ pellets produce RE current, MGI (usually) does not

Summary

→ Applied n=1 fields did not reverse mode phase during MGI TQ. May try large amplitude. DIII-D experiment planned for June; simulations at least predict some observable effect.

→ RE confinement results confirm MGI less likely to produce RE current plateau. Addition of realistic seed generation terms to NIMROD model (using CQL3D) is in progress.